Amendments to the Claims

1. (Previously presented) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

a first step, performed at least partially by atomic layer deposition, of depositing a barrier layer comprising tantalum on sides of said hole;

a second step of etching said barrier layer at a bottom of said hole selectively to said barrier layer on said sides of said hole;

a subsequent third step, performed by physical vapor deposition, of depositing a copper seed layer over said barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

2. (Original) The process of Claim 1, wherein said barrier layer comprises tantalum nitride.

3. (Cancelled)

4. (Previously presented) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

a first step, performed at least partially by atomic layer deposition, of depositing a barrier layer comprising tantalum on sides of said hole;

a subsequent second step of etching said barrier layer at the bottom of the hole, wherein second step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer;

a subsequent third step, performed by physical vapor deposition, of depositing a copper

seed layer over said barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

5. (Original) The process of Claim 4, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.

6. (Previously presented) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

a first step, performed at least partially by atomic layer deposition, of depositing a barrier layer comprising tantalum on sides of said hole, wherein said first step includes an initial CVD step for depositing a first part of said barrier layer and a subsequent sputtering step for depositing a second part of said barrier layer;

a second step, performed by physical vapor deposition, of depositing a copper seed layer over said barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

7. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the sequentially performed steps of:

a first step, performed by chemical vapor deposition, of depositing a first barrier layer comprising tantalum on sides of said hole;

a second step, performed by sputtering, of depositing a second barrier layer comprising tantalum on said sides of said hole;

a third step, performed by physical vapor deposition, of depositing a copper seed layer over said first and second barrier layers; and

a fourth step, performed by electrochemical plating, of filling copper into said hole over said copper seed layer.

8. (Previously presented) The process of Claim 7, wherein said chemical vapor deposition comprises atomic layer deposition.

9. (Original) The process of Claim 7, further comprising a fifth step performed after said first step performed in a sputter reactor of etching said first barrier layer at the bottom of said hole.

10. (Original) The process of Claim 9, wherein fifth step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer.

11. (Original) The process of Claim 10, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.

12. (Canceled)

13. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level diclectric layer, comprising the steps of:

depositing by a deposition process comprising chemical vapor deposition a nitrided barrier layer on sides of said hole;

in a sputter reactor including a tantalum target, etching said nitrided barrier layer on a bottom of said hole;

in said sputter reactor, depositing a material comprising tantalum on sidewalls of said hole to form a second barrier layer;

depositing by physical vapor deposition a copper seed layer over said second barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

14. (Original) The process of Claim 13, wherein said deposition process comprises atomic layer deposition.

15. (Original) The process of Claim 13, wherein said nitrided barrier layer comprises TiSiN.

16. (Original) The process of Claim 13, wherein said second barrier layer comprises TaN.

17 – 41. (Canceled)

42. (Previously presented) A method of filling one or more of a via and a trench in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer in one or more of the via and the trench on the patterned substrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials.

43. (Previously presented) The method of Claim 42, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.

44. (Previously presented) The method of Claim 43, wherein the first barrier layer comprises a material is selected from the group consisting of Ti, Ta, W, and nitrides thereof.

45. (Previously presented) The method of Claim 42, wherein the second barrier layer comprises at least one refractory metal selected from the group consisting of Ta and W.

46. (Previously presented) The method of Claim 43, wherein the seed layer comprises copper.

47. (Previously presented) The method of Claim 46, wherein the metal layer comprises is copper.

48 – 49. (Canceled)

50. (Previously presented) The method of Claim 43, wherein the seed layer is deposited by physical vapor deposition.

51. (Canceled) The method of Claim 43, wherein the metal layer is deposited by chemical vapor deposition.

52. (Previously presented) The method of Claim 43, wherein the metal layer is deposited by electroplating.

53. (Previously presented) The method of Claim 42, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN, and wherein the second barrier layer has a thickness of from about 2nm to about 5nm at the bottom of the via.

54. (Previously presented) A method of filling one or more holes in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by atomic

layer deposition;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials to fill the holes.

55. (Previously presented) The method of Claim 54, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the holes after the second barrier layer is deposited.

56. (Previously presented) The method of Claim 55, wherein the first barrier layer comprises a material selected from the group consisting of Ta, TaN, W, and WN.

57. (Previously presented) The method of Claim 56, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, T, TiN, W, and WN.

58. (Previously presented) The method of Claim 57, wherein the seed layer comprises copper.

59. (Previously presented) The method of Claim 58, wherein the metal layer comprises copper.

60. (Previously presented) The method of Claim 55, wherein the seed layer is deposited by physical vapor deposition.

61. (Previously presented) The method of Claim 55, wherein the metal layer is deposited by electroplating.

62. (Previously presented) The method of Claim 54, wherein the second barrier layer

comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN.

63. (Canceled)

64. (Currently amended) ~~The method of Claim 63~~ A method of filling one or more of a via and a trench in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition;

b) removing the first barrier layer from the horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.

65. (Previously presented) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on the bottom of the trench; and

d) then depositing one or more conductive materials.

66. (Previously presented) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by atomic layer deposition;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on a bottom of the trench; and

d) then depositing one or more conductive materials.

67. (Currently amended) The process of claim [[3]] 1, wherein said etching is performed with energetic ions.